(1,2), as well as several previously reported prospective drug "add-on" trials (3–6), provide very strong evidence of digoxin's clinical efficacy. The issue of digoxin's effect on survival must, as we pointed out in our article, be addressed (as is currently underway) to complete the drug's clinical profile.

BARRY F. URETSKY, MD
JAMES B. YOUNG, MD
M. K. JOLLY, PharmD
Catheterization Laboratory
D-324 Presbyterian University Hospital
Pittsburgh, Pennsylvania 15213

References

1. Uretsky BF, Young JB, Shahidi FE, Yellen LG, Harrison MC, Jolly MK. Randomized study assessing the effect of digoxin withdrawal in patients with mild to moderate chronic congestive heart failure: results of the PROVED trial. J Am Coll Cardiol 1993;22:955–62.
2. Packer M, Gheorghiade M, Young JB, et al. Randomized, double-blind, placebo-controlled, withdrawal study of digoxin in patients with chronic heart failure treated with converting-enzyme inhibitors. N Engl J Med 1993;329:1–7.
3. Captopril Multicenter Research Group. Comparative effects of therapy with captopril and digoxin in patients with mild to moderate heart failure. JAMA 1988;259:539–44.
4. Guyatt GH, Sullivan MJJ, Fallen EL, et al. A controlled trial of digoxin in congestive heart failure. Am J Cardiol 1988;61:371–5.
5. DiBianco R, Shabetai R, Kostuk W, Moran J, Schlant RC, Wright R, for the Milrinone Multicenter Trial Group. Oral milrinone and digoxin in heart failure: results of a placebo controlled prospective trial of each agent and the combination. N Engl J Med 1989;320:677–83.
6. German and Austrian Xamoterol Study Group. Double-blind placebo-controlled comparison of digoxin and xamoterol in chronic heart failure. Lancet 1988;1:488–92.

Synchronized Coronary Venous Retroperfusion

We would like to comment on the recently published report by Boekstegers et al. (1). We as scientists who have used the technique of synchronized coronary venous retroperfusion extensively, both experimentally and clinically, would like to caution the readers with regard to certain issues before they extrapolate these data clinically. Our concerns regard safety, feasibility and efficacy.

With respect to safety, it has been shown in several studies (2–4) that retroperfusion coronary venous pressures <40 mm Hg (mean pressure) and 60 mm Hg (peak pressure) were safe. The manufacturer also limits mean pressures at 40 mm Hg (5). In this study during retroperfusion/retroinfusion, the coronary venous pressures were as high as 89 ± 24 mm Hg for peak pressure and 61 ± 16 mm Hg for mean pressure (1 [Table 3]). In a previous publication, Boekstegers et al. (6) state that pressures >50 mm Hg are dangerous and lead to myocardial hemorrhage and edema. The authors did not observe any detrimental effects from these high pressures; however, the duration of pumping support retroperfusion in these studies was limited to 10 min. On the basis of previous clinical studies, and to ensure safety of the synchronized retroperfusion technique, the pump is actually equipped with a cutoff switch that shuts off the pump when unacceptably high pressures develop within the coronary veins (5). Also of note is that the rest pressures in the animal before the start of retroperfusion were high at ~20 mm Hg, indicating probable venous occlusion by the balloon-tipped 8.5F synchronized retroperfusion catheter, thus hampering venous drainage. Previous safety studies (2–4) demonstrate the importance of normal rest coronary venous pressure, which must equal right atrial pressure to ensure adequate venous drainage.

The feasibility of the synchronized retroperfusion technique encompassed the rapidity with which the technique can be set up and the catheter insertion time. Retroperfusion has been effective when the catheter is placed in the great cardiac vein. Selective cannulation of the anterior interventricular vein is not necessary. The authors suggest greater efficacy if the anterior interventricular vein is cannulated, which will make the technique more time-consuming and protection restricted to left anterior descending coronary artery territory. Retroperfusion is dependent on arterio-venous gradients; hence the retroperfusate will go toward the ischemic areas (low pressure) even without selective cannulation of the draining veins (7).

Boekstegers et al. (1) used intramyocardial oxygen tension and regional myocardial function using ultrasound crystals as end points. The efficacy with suction and retroinfusion did reach statistical significance, but we are unsure whether the degree of improvement is clinically relevant. The authors used a 10-min ischemia followed by a 50-min reperfusion model. This does not simulate a percutaneous transluminal coronary angioplasty model adequately, where there are repeated episodes of short ischemia. The 50-min reperfusion after 10-min occlusion was too short to cause myocardial necrosis or simulate an acute myocardial infarction. The study thus has limited clinical applicability.

The technique of synchronized coronary venous retroperfusion when applied properly and according to the instructions of the manufacturer (Retroperfusion Systems, Inc. [5]) has been shown to be safe, feasible and effective in numerous clinical trials (8–12). The manufacturer has recently been issued a letter of approval from the U.S. Food and Drug Administration on the basis of the safety guidelines and effectiveness of the technique. As scientists involved in the original experimental and clinical studies, we have great concern with regard to applicability of this technique by Boekstegers et al. (1).

SHEILA KAR, MD
Cedars Sinai Medical Center
Los Angeles, California

J. CRAIG BARNETT, MD
Cardiology of Southwest Virginia
Radford, Virginia

ROBERT J. FREEDMAN, Jr., MD
Freedman Clinic of Internal Medicine
Alexandria, Louisiana

BRYAN C. DONOHUE, MD
DAVID LASORDA, MD
Allegheny General Hospital
Pittsburgh, Pennsylvania

ALICE K. JACOBS, MD
Boston University Medical Center
Boston, Massachusetts

References

1. Boekstegers P, Peter W, von Degenfeld G, et al. Preservation of regional myocardial function and myocardial oxygen tension during acute ischemia in pigs: comparison of selective synchronized suction and retroinfusion of coronary veins to synchronized coronary venous retroperfusion. J Am Coll Cardiol 1994;23:459–69.

2. Meerbaum S, Lang TW, Osher JV, et al. Diastolic retroperfusion of acutely ischemic myocardium. Am J Cardiol 1976;37:588–98.
3. Drury JK, Yamazaki S, Fishbein MC, Meerbaum S, Corday E. Synchronized diastolic coronary venous retroperfusion: results of a preclinical safety and efficacy study. J Am Coll Cardiol 1985;6:328–35.
4. Farcot JC, Meerbaum S, Lang TW, Kaplan L, Corday E. Synchronized retroperfusion of coronary veins for circulatory support of jeopardized ischemic myocardium. Am J Cardiol 1978;41:1191–201.
5. Synchronized Coronary Venous Retroperfusion Device, Operation Manual, 1990–1994. Irvine, CA: Retroperfusion Systems, Inc.
6. Boekstegers P, Diebold J, Weiss C. Selective ECG synchronized suction and retroinfusion of coronary veins: first results of studies in acute myocardial ischemia in dogs. Cardiovasc Res 1990;24:456–64.
7. Meesmann M, Karagueuzian HS, Ino T, et al. Selective perfusion of ischemic myocardium during coronary venous retroinjection: a study of the causative role of venoarterial and venoventricular pressure gradients. J Am Coll Cardiol 1987;10: 887–97.
8. Kar S, Drury JK, Hajduczki I, et al. Synchronized coronary venous retroperfusion for support and salvage of ischemic myocardium during elective and failed angioplasty. J Am Coll Cardiol 1991;18:271–82.
9. Costantini C, Sampaolesi A, Serra CM, et al. Coronary venous retroperfusion support during high risk angioplasty in patients with unstable angina: preliminary experience. J Am Coll Cardiol 1991;18:283–92.
10. Incorvati RL, Tauberg SG, Pecora MJ, et al. Clinical applications of coronary sinus retroperfusion during high risk percutaneous transluminal coronary angioplasty. J Am Coll Cardiol 1993;22:127–34.
11. Barnett JC, Freedman RJ, Touchon RC, Mesner MR. Coronary venous retroperfusion of arterial blood for the treatment of acute myocardial ischemia. J Cath Cardiovasc Diagn 1993;28:206–13.
12. Nanto S, Nishida K, Hirayama A, et al. Supported angioplasty with synchronized retroperfusion in high-risk patients with left main or near left main trunk obstruction. Am Heart J 1993;125:301–9.

Reply

Kar et al. raise three issues with regard to our recent report (1). The first is the safety of peak and mean coronary venous pressures during retroperfusion. The definition of "mean" coronary venous pressure must be clarified because previous studies (2–5) did not differentiate between mean diastolic or systolic pressures. With regard to the data from our article, mean coronary venous pressure was not 61 mm Hg, as stated by Kar et al., but 50 mm Hg in the animals treated by synchronized retroperfusion, and it was only 34 mm Hg in the animals treated by selective suction and retroinfusion. Furthermore, obstruction of the great cardiac vein by the 8.5F retroperfusion catheter was excluded by previous determination of the rest pressures using a 5F catheter. In a previous report (6), we stated that 50 mm Hg was the *suggested* limit of coronary venous peak pressure by others (2–4). In these studies the suggested safety limits for long-term application (several hours) were derived from the experience of studies without adequate coronary venous drainage (7,8) but were not actually caused by inducing damage related to certain coronary venous pressures. Hence, the observation that using a limit of 50 or 60 mm Hg for peak or 40 mm Hg for mean coronary venous pressures was safe in experimental (2–4,6) and clinical studies (5,9–10) does not necessarily imply that higher pressures are harmful, in particular with regard to short-term (several minutes) application of retroinfusion, as demonstrated in our study. Furthermore, differences with regard to coronary venous wall stress may occur if pressure is reduced to zero intermittently by active suction during selective suction and retroinfusion compared with synchronized retroperfusion. Therefore, definitive upper safety limits for peak and mean coronary venous pressures in short- and long-term applications of coronary venous retroinfusion—in our opinion—are not yet clear, as stated by Kar et al.

The second issue is the feasibility of the selective suction and retroinfusion technique. It has been shown by several studies that the main difficulty using retroinfusion techniques was to enter the coronary sinus but not to advance into the great cardiac vein (5,9,10). Therefore, we don't believe that the selective suction and retroinfusion technique will be more time-consuming than synchronized retroperfusion, which is also supported by the fact that smaller catheter sizes used for selective suction and retroinfusion should make it easier to advance it into the smaller veins.

The third issue is the clinical efficacy of selective suction and retroinfusion and synchronized retroperfusion. Because our study was preclinical, we did not intend to anticipate any clinical conclusion. Our experimental results, however, suggest that selective suction and retroinfusion may indeed be more effective than synchronized retroperfusion in pigs. The finding of clearly superior preservation of regional myocardial function by selective suction and retroinfusion compared with synchronized retroperfusion (71% vs. 7% of baseline value) during the first minute of arterial occlusion suggests the clinical relevance of myocardial protection by selective suction and retroinfusion for application during short-term repeated percutaneous transluminal coronary angioplasty as well. Myocardial oxygen tension and regional myocardial function appeared to be more relevant variables for comparing the efficacy of selective suction and retroinfusion and synchronized retroperfusion in an experimental model of coronary angioplasty than the development of myocardial necrosis. Furthermore, we did not simulate myocardial infarction in this study because the efficacy of selective suction and retroinfusion in reducing myocardial necrosis has been demonstrated previously (6).

PETER BOEKSTEGERS, MD
WOLFGANG PETER, MD
KARL WERDAN, MD
Department of Medicine I
Grosshadern University Hospital
München, Germany

CHRISTOPH A. NIENABER, MD
Department of Cardiology
University Hospital Eppendorf
Hamburg, Germany

References

1. Boekstegers P, Peter W, von Degenfeld G, et al. Preservation of regional myocardial function and myocardial oxygen tension during acute ischemia in pigs: comparison of selective synchronized suction and retroinfusion of coronary veins to synchronized coronary venous retroperfusion. J Am Coll Cardiol 1994;23:459–69.
2. Meerbaum S, Lang TW, Osher JV, et al. Diastolic retroperfusion of acutely ischemic myocardium. Am J Cardiol 1976;37:588–98.
3. Drury JK, Yamazaki S, Fishbein MC, Meerbaum S, Corday E. Synchronized diastolic coronary venous retroperfusion: results of a preclinical safety and efficacy study. J Am Coll Cardiol 1985;6:328–35.
4. Farcot JC, Meerbaum S, Lang TW, Kaplan L, Corday E. Synchronized retroperfusion of coronary veins for circulatory support of jeopardized ischemic myocardium. Am J Cardiol 1978;41:1191–201.
5. Kar S, Drury JK, Hajduczki I, et al. Synchronized coronary venous retroperfusion for support and salvage of ischemic myocardium during elective and failed angioplasty. J Am Coll Cardiol 1991;18:271–82.
6. Boekstegers P, Diebold J, Weiss C. Selective ECG synchronized suction and retroinfusion of coronary veins: first results of studies in acute myocardial ischemia in dogs. Cardiovasc Res 1990;24:456–64.
7. Hammond GL, Davies AL, Austen WG. Retrograde coronary sinus perfusion: a method of myocardial protection in the dog during left coronary artery occlusion. Ann Surg 1967;166:39–47.
8. Demos S, Brooks H, Holland R, et al. Retrograde coronary venous perfusion to reverse and prevent acute myocardial ischemia [abstract]. Circulation 1974;49/50 Suppl III:III-168.